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Tumor Bed Brachytherapy With a Mesh Template: An Accessible Alternative to Intraoperative Radiotherapy

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Background and Objectives: Locally advanced and recurrent malignancies often require adjuvant radiotherapy to achieve tumor control. We report our experience with a technique that uses an intraoperatively placed mesh template for the delivery of radiotherapy.

Methods: from 1988 to 1996, 14 patients were treated with tumor bed brachytherapy using this mesh technique. Sites of involvement included the head and neck region (n = 6), abdomen/pelvis (n = 4), retroperitoneum (n = 3), and the lower extremity (n = 1). During surgery, plastic catheters were evenly placed within a mesh template (Vicryl or Marlex), which was positioned in the tumor bed. The catheters were afterloaded with radioactive sources once the final pathology had been determined and the patient required limited nursing care. Radiation dose was titrated to the surgico-pathologic findings (e.g., margin status).

Results: All of the patients tolerated the procedure without experiencing acute or chronic sequelae. The median survival time was 13 months. Local control was achieved in 11 of 13 evaluable patients, with an actuarial local control of 82% at 6 months.

Conclusion: Tumor bed brachytherapy with a mesh implant is a practical technique to improve tumor control and warrants further investigation.

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KEY WORDS: **adjuvant radiotherapy; iridium-192; brachytherapy; mesh; radiotherapy**

INTRODUCTION

Locally advanced and recurrent malignancies often present formidable challenges in the management of cancer patients. Although surgical resection remains the cornerstone of treatment for many locally advanced malignancies, postoperative residual disease may require adjuvant therapies. Local failures following surgical resection may be related to the extent of tumor present before the resection, the adequacy of surgical margins, and the biology of the specific malignancy. External beam radiotherapy can be added to improve local control in the context of positive margins of resection. However, tumor control may be reduced when only moderate doses of irradiation can be safely delivered due to tolerance limits of adjacent normal tissues [1–3].

Interstitial brachytherapy refers to the surgical implantation of radioactive sources into a defined target volume. Brachytherapy applications are made difficult when large irregular volumes must be implanted following surgery. Such target shapes predispose to the development of inhomogeneous dose regions with significant differences in prescribed dose. To avoid this dilemma, we have used a novel means of perioperative tumor bed brachytherapy that involves the weaving of evenly spaced catheters into a mesh template in order to conform the radiation dosimetry to the target as defined by the surgeon in situ. This approach also reduces anesthesia time in compari-

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TABLE I. Mesh Brachytherapy: Patient Characteristics

Patient no.	Age	Sex	Tumor site	Dose implant (Gy)	EXRT[a] (Gy)	Status last follow-up[b]
1	60	M	Recurrent tongue carcinoma (neck)	30	60[c]	NED, 2.5 yr
2	74	M	Recurrent thyroid carcinoma (neck)	38	0	LC, DOD at 2 mo
3	72	F	Retroperitoneal sarcoma	25	45[d]	NED, 1 yr
4	60	F	Recurrent colon carcinoma	21	45[d]	LC, DOD at 1 yr
5	65	M	Retroperitoneal sarcoma	26	45[d]	NED, 1 yr
6	69	M	Recurrent soft palate carcinoma	25	70[c]	Marginal LF at 6 mo, DOD at 18 mo
7	48	F	Lower extremity sarcoma	25	45[d]	NED, 2 yr
8	46	F	Recurrent ovarian carcinoma (pelvic side wall)	20	51[d]	NED, 9 yr
9	60	F	Endometrial carcinoma (pelvis and psoas muscle)	25	43[d]	LC, DOD at 26 mo
10	51	M	Retroperitoneal sarcoma	14	0	DOD at 2 mo
11	63	F	Recurrent lacrimal/soft palate and neck carcinoma	30 & 35	0	LF, DOD at 6 mo
12	59	F	Recurrent gallbladder carcinoma	35	40[c]	NED, 1 yr
13	50	M	Recurrent laryngeal carcinoma (neck)	30	65[c]	LC, DOD at 3 mo
14	60	M	Recurrent oral tongue carcinoma	30	59[c]	LC, dead of intercurrent disease at 15 mo

[a]External beam radiotherapy.
[b]NED = No evidence of disease; LC = locally controlled; DOD = dead of disease; LF = local failure.
[c]Prior EXRT.
[d]Adjuvant EXRT.

son to conventional brachytherapy procedures, because catheters do not have to be individually secured with suture material. This report describes the technical aspects of this tumor bed brachytherapy approach and its associated practical value.

MATERIALS AND METHODS

Between 1988 and 1996, 14 patients with locally advanced or recurrent malignancies underwent tumor bed brachytherapy at Pennsylvania Hospital. Patient and tumor characteristics are described in Table I. All patients had informed consent obtained prior to treatment. Once a preoperative diagnosis of malignancy was established, patients were brought to surgery for tumor debulking. Once the surgical field was evaluated, measurements were taken of the tumor cavity in order to configure the implant. Plastic catheters (Best Industries, Springfield, VA) were subsequently woven into a mesh template at 1 cm intervals. This was performed simply by advancing the catheters manually through the mesh. The template material usually consisted of Vicryl (absorbable [Ethicon Inc., Summerville, NJ]), but occasionally a nonabsorbable material (i.e., Marlex) (C.R. Bard, Inc., Billerica, MA) was used. The mesh template and evenly spaced catheters formed a uniform single plane implant. Once the surgeon and radiation oncologist properly positioned the implant to encompass potential areas of residual disease, the surgical site was closed with the catheter ends exiting the surgical site or through a separate drain site. The closed end of the plastic catheters was left inside the patient and the open end exited the body. In the pelvis, omentum was placed over the mesh to protect the small bowel. Figure 1 illustrates the described catheters woven through a Vicryl mesh.

After the surgery was completed and a final histologic diagnosis was established (usually within 2 days), brachytherapy treatment planning was undertaken. Localization radiographs were obtained with radiopaque ‘‘dummy’’ sources placed within the catheters in order to calculate the appropriate radiation dosimetry. Figure 2 represents a radiograph of a mesh implant in a subtotally resected retroperitoneal sarcoma. Dummy seeds are placed in the catheters for representative dosimetric calculations.

After the prescribed dose (calculated at 0.5 cm from

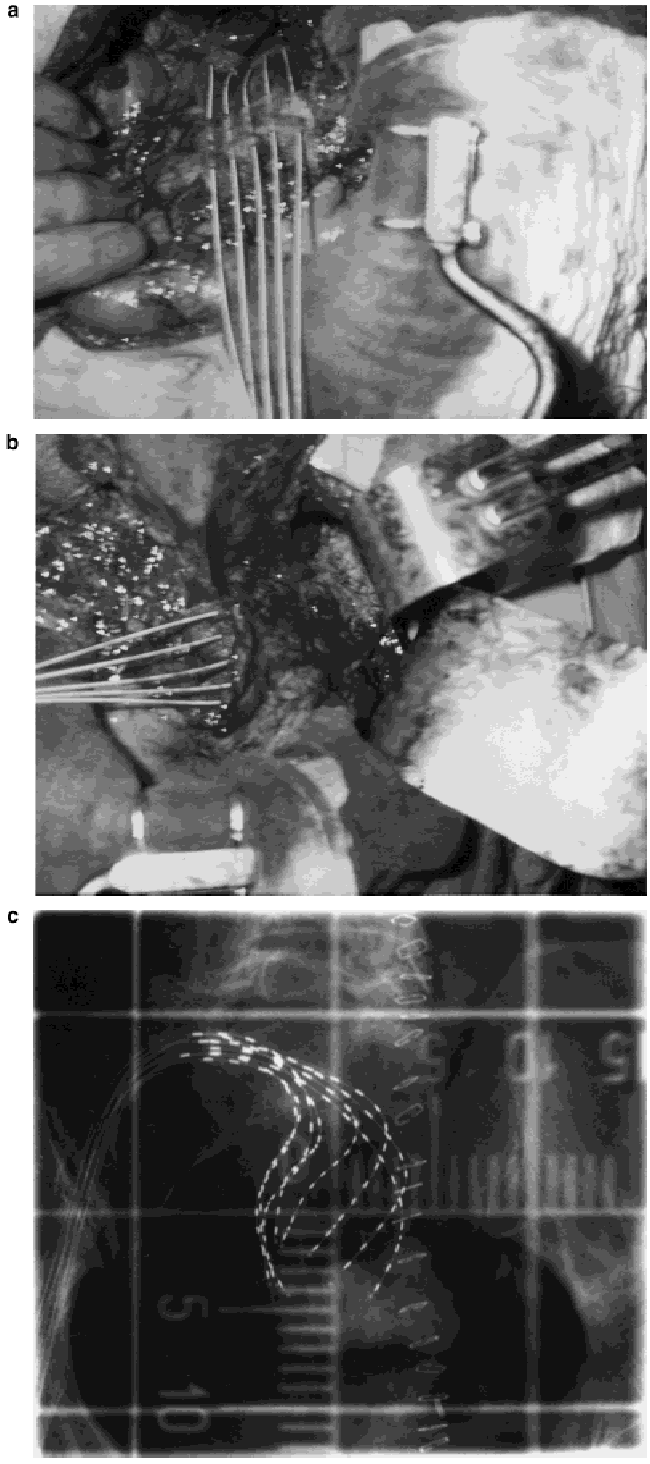

Fig. 1. **(a)** Recurrent carcinoma of the sigmoid colon with dummy catheters in place for localization (Patient No. 4). **(b)** Omentum positioned over the implant to protect small bowel (Patient No. 4). **(c)** Radiograph of the mesh implant for the same case (Patient No. 4).

the plane of the implant) and treatment time were determined using the CMS Modulex (Computer Medical Systems, St. Louis, MO) treatment planning system, the ribbons containing radioactive Iridium-192 were threaded into the hollow plastic catheters and secured in place with metal buttons at the end of the tubes. This was performed in the patient's hospital room with minimal radiation exposure to hospital personnel. Iridium-192 sources were used for all cases reported. At the completion of the implant, the sources and hollow catheters were removed. The absorbable Vicryl mesh was left to spontaneously dissolve, and the Marlex was simply left in place.

RESULTS

During the period of study, 14 patients were implanted with the mesh template technique (Table I). The median patient age was 60 years (range: 46–74). The most common sites implanted included the head and neck (n = 6), retroperitoneum (n = 3), and pelvis (n = 3). The other sites implanted included the abdomen (i.e., gallbladder) and the lower extremity.

The median additional time required to place the mesh with catheters intraoperatively was 20 minutes (range: 15–40 minutes). The median number of catheters placed was 6 (range: 4–11). Five of the patients had received previous radiotherapy. Six of the patients received external beam irradiation in addition to the implant (median dose = 45 Gy; range: 43–51 Gy). The median brachytherapy dose, prescribed at 0.5 cm, was 26 Gy (range: 14–39 Gy). The median hospital stay was 7 days (range: 3–15 days).

The median survival time in this series was 13 months. Although six patients developed progressive distant disease, 11 of 13 patients have maintained local disease control at the site of the implant at a median follow-up of 13 months. Excluding one patient (No. 10) who prematurely discontinued treatment, the actuarial local control was 82% at 6 months with no subsequent failures thereafter in the 13 evaluable patients (Fig. 3). One failure arose at the margin of a head and neck field in a patient who underwent several local excisions for recurrent disease prior to the implant. The other local failure occurred in a patient who had previously received treatment (re-resection and external beam irradiation) for recurrent disease in the oral tongue and neck. Of five patients who recurred following prior radiotherapy, four were successfully salvaged locally using this mesh technique. No chronic morbidity attributable to the procedure has been documented. Another patient (No. 12) developed an acute side effect characterized by erythema of the overlying skin following implant of the neck, which resolved on intravenous antibiotics. Of note, one patient (No. 10) received only 14 Gy of a planned 25 Gy implant and 45 Gy external beam because he pulled out the catheters and refused further treatment. He died shortly thereafter from widespread abdominal sarcoma and was not considered evaluable for efficacy or toxicity.

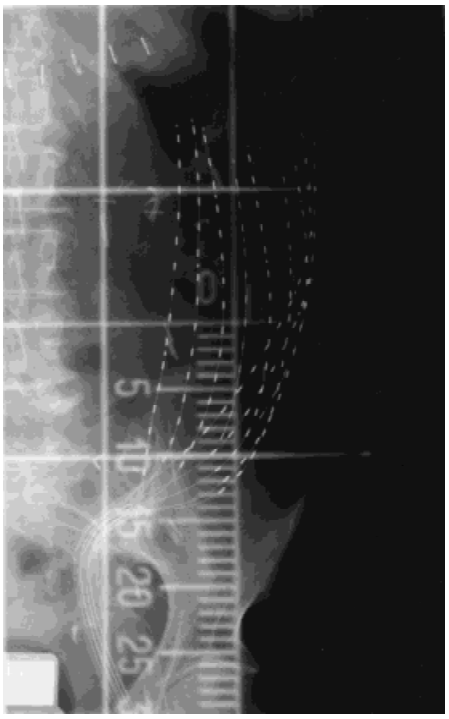

Fig. 2. Radiograph of a mesh implant for a retroperitoneal sarcoma (as described in the reported case, Patient No. 3).

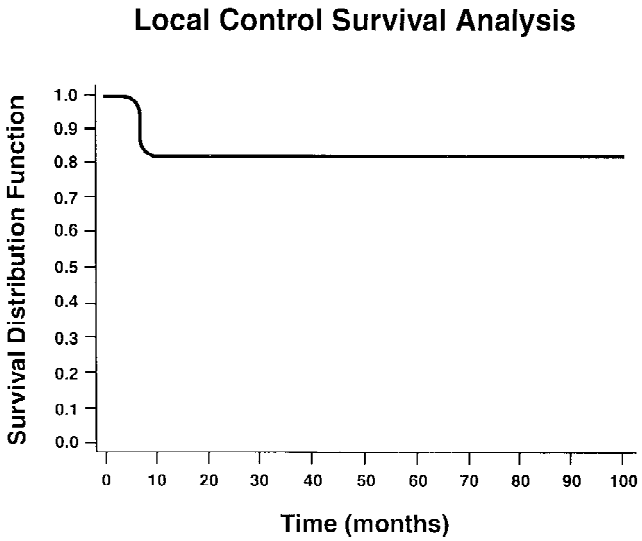

Fig. 3. Actuarial local control of the 13 patients treated with mesh template brachytherapy.

CASE REPORT

Patient No. 3 is a 72-year-old female who presented in October 1995 with vague complaints of lower back and abdominal pain. Evaluation included a CT scan of the abdomen and pelvis, which revealed a large, heterogeneous mass in the left retroperitoneum, suggestive of sarcoma. No distant metastases were detected. On 11/8/95, the patient underwent surgical resection of the retroperitoneal mass in the operating room. Following gross total excision of the mass (which included the ipsilateral kidney), the tumor cavity was measured to be 10 × 10 cm. Ten plastic catheters were subsequently place in a vicryl mesh at 1 cm spacing intervals. After the mesh was adequately prepared with the catheters, the attending radiation oncologist and surgeon sutured the mesh into the tumor bed. Omentum was placed over the mesh to protect the small bowel from the sources of radiation. The patient was brought to the recovery room after surgical closure. Iridium sources were then ordered for loading on hospital day 3. The final pathology was reported as moderately differentiated liposarcoma with involvement of the margins throughout the specimen. Ten catheters were loaded with 10 ribbons containing a total of 155 seeds of Iridium-192 (Fig. 2). Dosimetric calculations indicated an overall treatment time of 50 hours specified to the 50 cGy/hour isodose line using the CMS Modulex treatment planning system. Accordingly, the implant was removed on 11/13/95 after 25 Gy were delivered to the primary site. The patient was discharged after recovery was completed on hospital day 9. On 12/2/95, a course of external beam irradiation was initiated. Using a 3-D algorithm, conformal fields were used to deliver an additional dose of 45 Gy. The patient tolerated her treatment without complications and she remains without evidence of disease as of August 1997.

DISCUSSION

Curative treatment of most solid neoplasms often requires either surgery, radiotherapy, or a combination of the two modalities. A prerequisite for curative therapy is local eradication of tumor [4]. Failure to achieve local control is potentially associated with increased local symptomatology and may even engender distant metastases [5,6]. Multiple clinical studies have generated dose-response curves attempting to relate the amount of irradiation needed to achieve local tumor control with a high degree of probability. A limiting factor in dose escalation is the need to respect the tolerance levels of the surrounding critical structures to a given level of radiation dose. The dose of irradiation tolerated by specific organs is also related to the volume of tissue irradiated.

Several creative strategies have been developed to deposit high doses of irradiation in the target tissue while simultaneously sparing the adjacent normal structures. Intraoperative radiotherapy (IORT) usually connotes the docking of the linear accelerator with a specialized cone attachment into a body cavity. Prior to IORT, the surgeon attempts to displace sensitive structures or introduce temporary shielding devices. The procedure has found a limited niche in clinical oncology [7–9]. Unfortunately, IORT is expensive and can add a considerable amount of anesthesia time. In addition, IORT requires more plan-

ning prior to the operative case than the currently described procedure. Accordingly, IORT is only available in a limited number of specialty centers.

Brachytherapy involves the use of ionizing radiation at limited distances in order to reduce the volume of exposure. In so doing, tumor control is often enhanced and toxicity reduced to surrounding tissues [10]. The concept of catheter placement with Iridium was initially described by Henschke et al. [11] in 1963. The technique has since been modified to account for the large irregular surfaces contours encountered at the time of surgical resection. It is axiomatic that the dose distribution of an interstitial brachytherapy application depends on the geometry of the radioactive sources comprising the implant. The use of the mesh template assures catheter immobilization with equal spacing of the sources, thereby permitting a tailored dose profile without unexpected inhomogeneous dose distributions. In our series, patients often received doses in excess of 70 Gy with no reported toxicity and excellent control rates at a median follow-up of 13 months. This improved therapeutic ratio would be difficult to reproduce if treatment solely entailed external beam treatments due to the higher risk of morbidity associated with treatment of adjacent normal tissues. In addition, for patients with recurrent disease following external beam radiotherapy, therapeutic doses with acceptable tolerance were delivered in already treated tissue. The present technique also facilitates aggressive perioperative treatment of residual malignant cells at a time when the cells are optimally oxygenated and theoretically more responsive to irradiation [12]. Further, this technique assures delivery of maximal tumor dose to the plane where the residual tumor cells are most apt to lie. Finally, treatment time is rapid and easily completed within a short hospitalization.

The tumors reported here are representative of the clinical problems for which dose escalation strategies in general, and brachytherapy solutions in particular, have been offered. For instance, in a review of patients treated for retroperitoneal sarcoma, Fein et al. [13] showed a strong statistical trend favoring the use of dose escalation with intraoperative radiotherapy. Harrison et al. [10] reported long-term results of a prospective randomized trial that demonstrated a significant local control advantage for patients with high-grade sarcomas treated with brachytherapy. Most interdisciplinary oncology programs in the United States, however, do not have access to IORT and few oncologists encounter a sufficient number of complex sarcoma cases to allow the confident design of complex freehand interstitial implant as practiced by Harrison et al. [10]. In contrast, the primary appeal of the current approach lies in the very simplicity of the procedure, which can be easily extrapolated by most practicing oncologists. Moreover, the investment is minimal and preplanning is not required. It should be noted that Meerwaldt et al. [14] described the technical feasibility of perioperative brachytherapy using a mesh template in eleven patients with advanced pelvic tumors. Hsi et al. [15] reported a similar experience using brachytherapy catheters in two patients with soft tissue sarcomas. The current study is the first to report outcome data on a moderate number of patients treated with a mesh template.

The brachytherapy technique described in this report provides a simple but effective way safely to increase the local dose of ionizing radiation. It minimizes the potential for unnecessary irradiation. For instance, in one situation, the preoperative diagnosis by fine-needle aspiration was thought to be a soft tissue sarcoma; however, the final pathology was signed out as benign. Accordingly, the catheters were easily removed postoperatively and no radiation was delivered. Furthermore, the procedure is appealing because no radiation preplanning is needed. The amount of time spent on a typical implant placement during surgery rarely exceeded ½ hour. In-patient management requires minimal nursing attention and exposure. Although concerns regarding wound healing have been raised [16], this complication did not manifest in the present series.

In summary, the simple technique described permits clinical flexibility and significant cost savings relative to IORT. It allows administration of intraoperative-like radiotherapy without the requisite technical resources needed for IORT that are usually available only in a tertiary setting. Further application of this technology is worthy of study.

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